Space Weather Technical Forecast

Issued on Sunday, 26 February 2023 at 13:02 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: G1-G2 Minor to Moderate storms, and a chance G3 Strong Storms late 26 Feb or 27 Feb, due to CME arrivals. R1-R2 Blackouts expected throughout, with a slight chance R3.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Moderate with two M-flares in the last 24 hours, peaking M6.3 at 25/1944 UTC from AR3229 with an associated filament eruption near the spot. There are currently seven sunspot regions on the visible disc. AR3234 remains the longest and largest spot, with some penumbral growth in its large leader spot, and a 'delta' spot is present in its trailer portion. AR3236 is the second largest region on the disc, which has shown some growth in its intermediate spots. This region also contains a 'delta' spot in its leading portion. This region appears to be elongated and perhaps rather unstable. AR3229 has shown continued decline in recent hours, though its magnetic field lines remain complex since the recent M6.3 flare. The remaining regions on the disc are small and simple.

Solar Wind / Geomagnetic Activity: Solar winds, as measured by DSCOVR and ACE at L1, have been at slightly elevated levels, ranging between 400-450 km/s, before recently increasing to near elevated levels, due to the arrival of a CIR ahead of negative polarity CH79, with speeds currently around 500 km/s. Density was mostly at average levels, before a rapid increase to above average levels from 25/2100 UTC, due to the arrival of the CIR ahead of HSS/CH79, with max of 33ppcc at 26/0700 UTC, before a gradual decline back to average, entering into the HSS. The total IMF strength, Bt, started weak, becoming mostly moderate from 25/1700 UTC. The north-south component was mostly negative, with a prolonged period of weak-moderate negative between 25/1400-1900 UTC, varying between +8 to -8 nT. Phi angle was mainly positive throughout (away from the Sun), but recently became negative (from 26/0700 UTC) due to the arrival CIR and the HSS from negative polarity CH79. Geomagnetic activity increased from Quiet (Kp 2) to become Unsettled or Active (Kp 3-4) to end the period.

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10 MeV) as measured at GOES-16, increased due to the arrival of high energy protons from the M6.4 flare and filament eruption originating from AR3229 around 25/1930 UTC. This is currently still rising, but breached the S1 Minor Storm threshold at 25/2110 UTC. High energy electron flux (greater than 2MeV) at GOES-16 was at Moderate levels, peaking of around 966pfu at 26/1800 UTC. The associated 24-hour electron fluence has been below the Active (1e8 integrated pfu) threshold on a slight rising trend, reaching 2.16e7 integrated pfu at 26/0000 UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Moderate activity is forecast to continue with further M-flares expected (R1-R2), and a slight chance of increasing to High if any X-flares occur (R3).

Solar Wind / Geomagnetic Activity: There are potentially two Earth directed CMEs in the forecast, the first is expected to arrive later on day 1 (26 Feb) and the second may arrive on

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days 2 or 3 (27 or 28 Feb). Earth has now entered into a high speed stream from CH79, following a recent CIR ahead of it. Solar winds are currently elevated, above 500km/s, which are likely to increase further with the arrival of a CME later on 26 Feb, which may bring speeds up to 600-700km/s. The Second CME may bring solar wind speeds between 500-650 km/s during the 27 or 28 Feb. Mainly Quiet conditions are expected to increase on day 1 (26 Feb) to Unsettled to Active with a chance of G1 Minor Storms due to fast from CH79. This is likely to rise further to give the chance of G1/Minor to G2/Moderate Storms due to the CME arrival, and a chance of an isolated G3/Strong Storm interval. Initial CME effects may ease later 27 Feb or into 28 Feb though the arrival of the CME from 25 Feb brings a further chance of G1/Minor or G2/Moderate storms and a slight chance of a further G3/Strong storm from late 27 Feb until early 01 Mar.

Energetic Particles / Solar Radiation: High energy (greater than 10 MeV) proton flux is currently above S1 Minor Storm levels due to the M6.3 flare from AR3229 on 25/1930 UTC. Proton levels are expected to gradually ease back towards background levels, over coming days. However there is a slight chance of further enhancements towards, or above the S1 Minor Storm threshold. High energy electron flux (greater than 2MeV) will be influenced by both coronal hole fast winds and CMEs through the end of Feb. As elevated winds decline later in the period, electron counts may begin to recover, with flux increasing to Moderate, and perhaps High (above 1000 pfu) by 28 Feb or 01 Mar. The associated 24 hour fluence is consequently expected to persist at background for much of the period, with an increasing chance of reaching Active levels toward the end of Feb or early Mar due to the uncertainty of CME arrivals.

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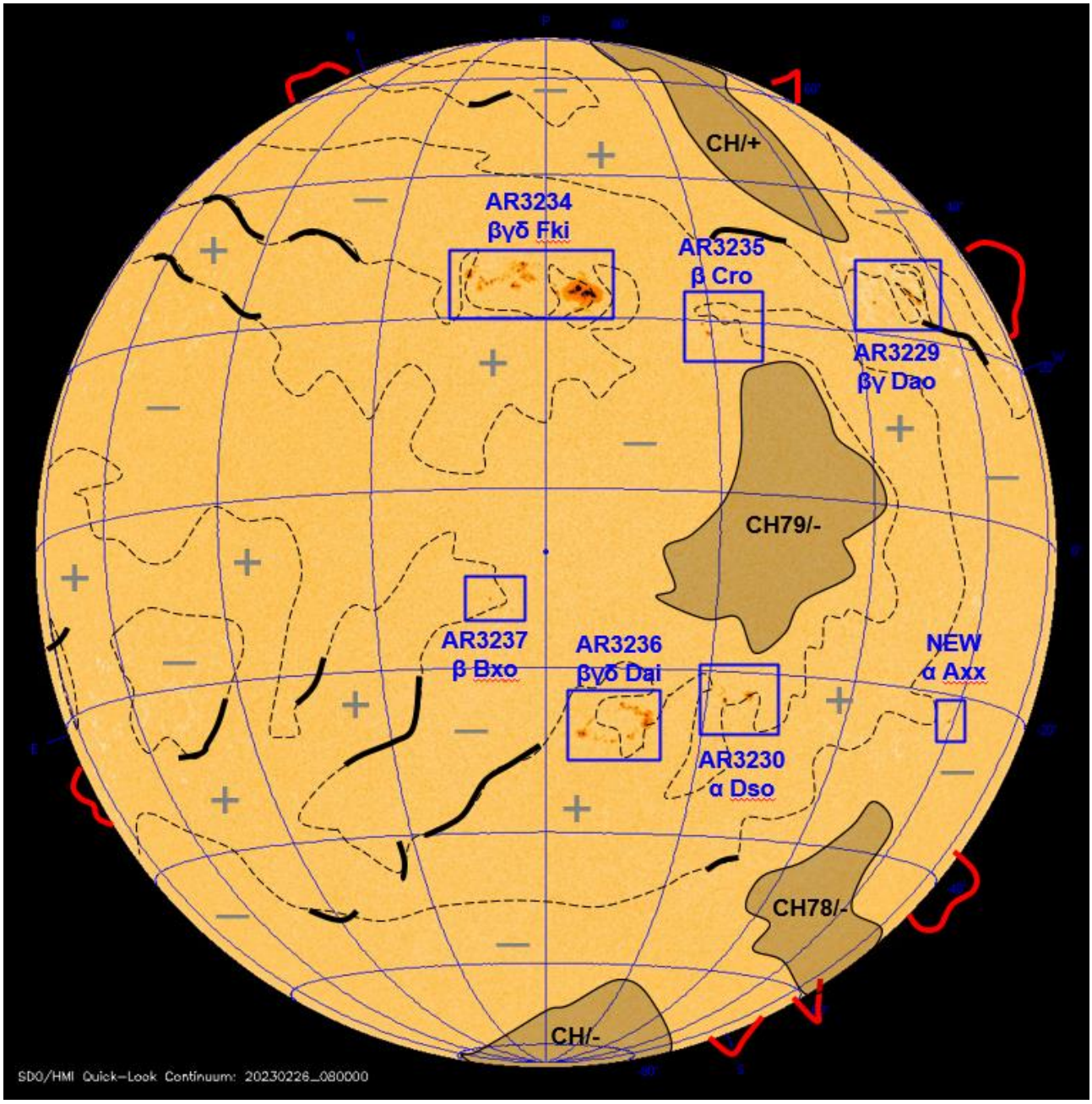
Figure 1. Solar Analysis Valid 26/0800 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

A CME which left the Sun around 24/0300 UTC due to the M3.7 flare and filament eruption near AR3229 has been analysed as having a likely arrival at Earth 26/1800 UTC +/- 6hrs. The bulk of the ejecta from this event has been modelled as passing over Earth, with a likely glancing shock arrival instead, however this is low confidence and there is the potential for a more impactful arrival.

Another CME left the Sun around 25/1930 UTC associated with a M6.3 flare from AR3229. This has been analysed and modelled, although there appears to be two possible solutions, with a mostly westward directed ejecta. There seems to be a likely Earth directed component associated with the CME, with arrival of this on either on day 2 or 3 (27 or 28 Feb).

Earth has now entered a HSS from CH79, after the arrival of a CIR ahead of this feature. Solar winds are currently elevated, just above 500 km/s. Wind speeds are expected to range between 500-600 km/s as signaled in ENLIL, given the negative polarity of the hole and the approaching March equinox, a strong connection is likely.

The HSS from CH79 coupled with a coincident CME arrival later on day 1 (26 Feb) have the potential to give a notable geomagnetic response. Geomagnetic activity is currently Unsettled, with an expected increase to Active levels, with a chance of G1 Minor Storms, due to HSS/CH79. Geomagnetic activity is expected to rise further to give a spell of G1/Minor to G2/Moderate Storms due to the CME arrival, and a chance of an isolated G3/Strong Storm interval. Any initial CME effects may ease later 27 Feb or into 28 Feb though the arrival of the CME from 25 Feb brings a further chance of G1/Minor or G2/Moderate storms and a slight chance of a further G3/Strong storm.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	70	70	50	30
Strong	G3	No	30	30	10	1
Severe	G4	No	5	5	1	1
Extreme	G5	No	1	1	1	1

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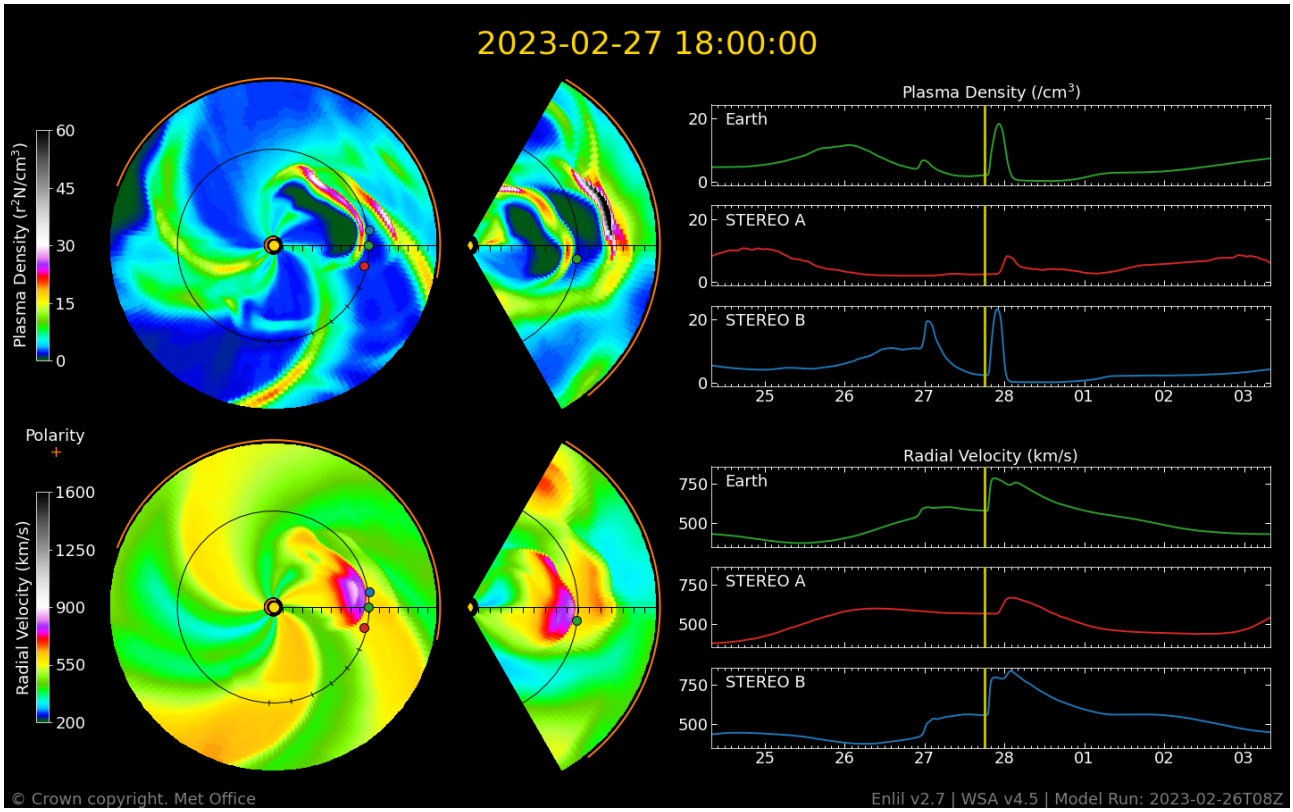
Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
24/2315	Partial	M3.7 Filament eruption	NW	1250 km/s	26/1800 +/- 6 hrs	Bulk material missing to north. Arriving during CH HSS
25/2330	Partial	M6.4 Flare and filament eruption	NW	600-1000 km/s	27/1800-28/2100	Most of ejecta missing. Further analysis on-going.

Figure 2: MOSWOC ENLIL



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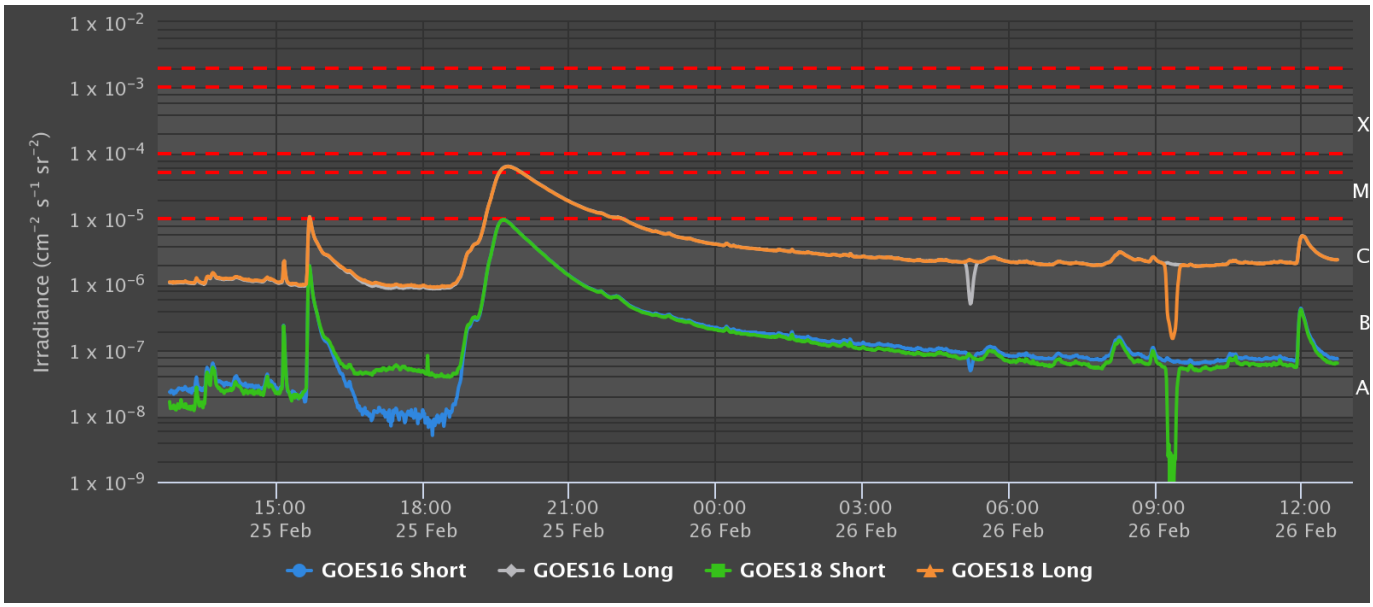
Radio Blackouts - X-Ray Flares:
Moderate activity is forecast to continue with further M-flares expected (R1-R2), and a slight chance of increasing to High if any X-flares occur (R3).

There are currently seven sunspot regions on the visible disc. AR3234 remains the longest and largest spot at present, with some penumbral growth in its large leader spot, and a 'delta' spot is present in its trailer portion. AR3236 is the second largest region on the disc, which has shown some growth in its intermediate spots. This region also contains a 'delta' spot in its leading portion. This region appears to be elongated and perhaps rather unstable. AR3229 has shown continued decline in recent hours, though its magnetic field lines remain complex following the M6 flare. The remaining regions on the disc are small and simple.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	80	70	60	60
Very Active	R3 to R5 X Class	No	15	15	10	10

Figure 3: X-Ray Flares



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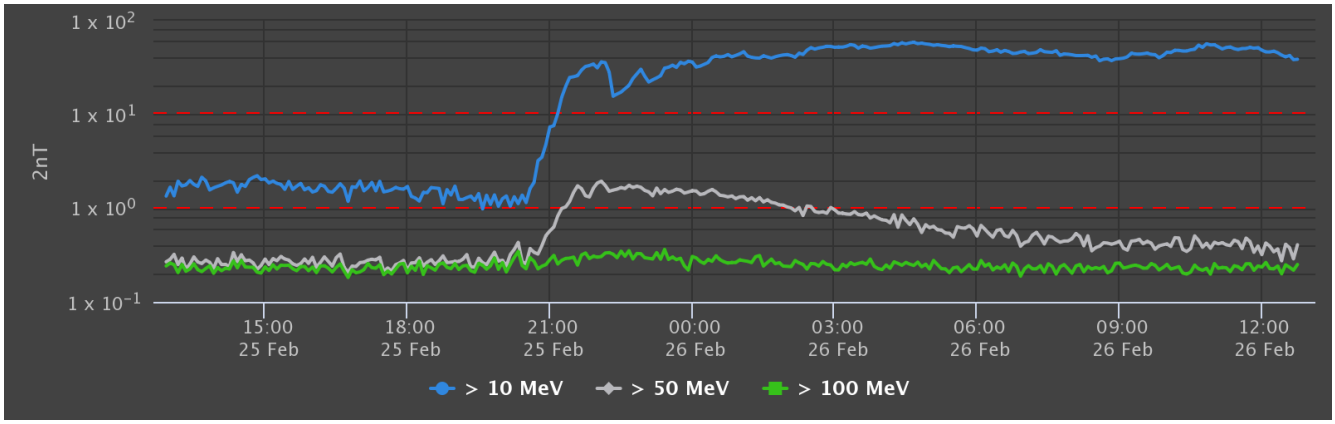
Solar Radiation Storms - (High Energy Protons):
High energy (greater than 10MeV) proton flux, as observed by GOES16, rose above the S1 Storm levels, with a peak of 58.8 pfu at 26/0440 UTC in response to the M6.4 flare and subsequent filament eruption from AR3229. The count rate remains above S1 levels at the time of writing, this likely continuing initially, though gradually waning through day 1 (26 Feb). Further proton events are possible, either from this sunspot region or from the other complex regions on the disc, including AR3234, which and AR3236 which are both moving into a more geoeffective location. This gives a slight chance of exceeding the S1 Minor Radiation Storm threshold from 27 Feb to 01 Mar.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	Yes	99	50	30	20
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 4: GOES-16 Proton Flux



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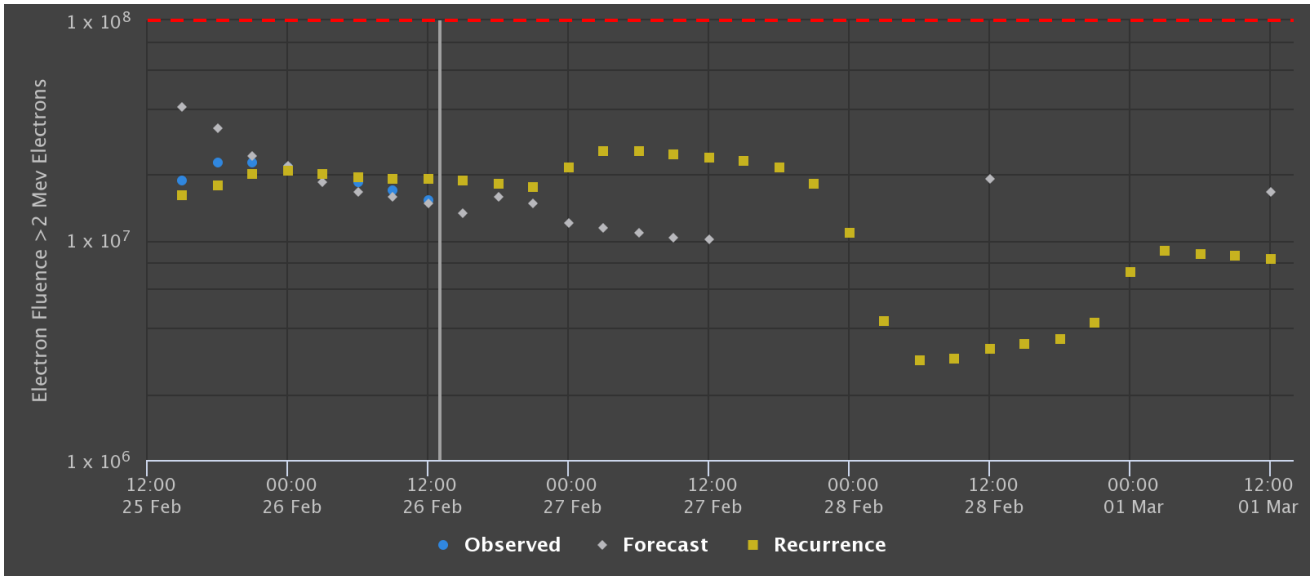
High Energy Electrons Event (≥ 2MeV):
High energy electron flux (greater than 2MeV) observed at GOES16 has returned back to background levels after spending much of the past 24 hours at Moderate levels, due to recent coronal hole enhancements. Coronal hole fast wind and CMEs through the end of Feb will likely combine to suppress observed flux at GEO, though perhaps increasing the electron content of the Van Allen belts which will be compressed into lower orbits. As elevated winds decline later in the period, these may begin to recover, with flux increasing to Moderate, and perhaps High (above 1000 pfu) by days 3 and 4 (28 Feb or 01 Mar).

The associated 24 hour fluence is consequently expected to persist at background days for much of the period, with an increasing chance of reaching Active levels toward the end of Feb due or early Mar to the uncertainty of CME arrivals. REFM is currently giving good guidance through the period with a mostly flat trend.

GEO Electron Environment	Level ($cm^{-2}\ sr^{-1}\ day^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ $1x10^8$	No	1	10	20	30
Very Active	≥ 2 MeV ≥ $1x10^9$	No	1	1	1	1

Figure 5: MOSWOC REFM and observations.



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